

APPENDIX B – METHODOLOGY AND RESULTS FROM SOCIOECONOMIC MODELING

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ECONOMIC ANALYSIS METHODOLOGY AND VALIDATION

TVA produces its own forecasts of regional economic activity. These forecasts are based on forecasts of the national economy developed by an internationally recognized forecasting service, *Global Insight*. TVA uses its regional economic forecasts for budget planning, the planning of locks and other navigation facilities, and economic development activities. These forecasts are publicly distributed throughout the Tennessee Valley. The regional economic forecasts are the major "key assumptions" to TVA's load forecasts.

These forecasts are based on five elements necessary for state-of-the-art forecasting: accuracy, use of best information, use of best methods, explicit treatment of uncertainty, and continuous improvement.

Accuracy

Table 1 below summarizes the accuracy of TVA's five-year forecasts for total gross product (the dollar value of all goods and services produced in a geographic area) for the region and the nation. (*Global Insight* and its predecessors *DRI* and *WEFA* have been used for the national economic forecasts.) These forecasts have been produced and documented annually since 1980. For example, regional and national forecasts for 1985 (the target year in Table 1) were done at the start of 1981, with 1980 as the latest historical year (the year of forecast in Table 1). Likewise, forecasts for 1995 were done at the beginning of 1991, with 1990 as the latest historical year. Table 1 shows the percent of error between the forecasted value and actual data, expressed as a positive (forecast was too high) or negative (forecast was too low) value, for both the regional and national forecasts.

Table 1 indicates that the performance of TVA regional economic forecasts has improved considerably since its early years, and that it has overall been favorable compared to that of the national economic forecasts. For the last three target years for which actual data are available for both the region and the nation (1998 through 2000), the average error in the regional forecasts for total gross product was small, within plus or minus 2 percent. An appendix table to this paper further describes the "track record" of the economic forecasts by exhibiting the average absolute percentage error for additional economic variables and forecasted target years.

Table 1
TVA Economic Forecast Five-Year Forecast Error
Gross Product in Billions of Dollars

Year of Forecast	Target Year	-----Regional-----			-----National-----		
		<u>Forecast</u>	<u>Actual</u>	<u>Forecast Error</u>	<u>Forecast</u>	<u>Actual</u>	<u>Forecast Error</u>
1980	1985	\$115.6	\$99.9	15.7%	\$4,840	\$4,213	14.9%
1981	1986	\$125.6	\$103.1	21.9%	\$5,278	\$4,453	18.5%
1982	1987	\$122.2	\$113.4	7.8%	\$5,278	\$4,742	11.3%
1983	1988	\$130.7	\$122.1	7.0%	\$5,348	\$5,108	4.7%
1984	1989	\$135.3	\$128.6	5.2%	\$5,709	\$5,489	4.0%
1985	1990	\$139.3	\$133.6	4.3%	\$5,896	\$5,803	1.6%
1986	1991	\$150.0	\$142.8	5.0%	\$6,367	\$5,986	6.4%
1987	1992	\$155.1	\$156.4	-0.8%	\$6,439	\$6,319	1.9%
1988	1993	\$172.2	\$166.0	3.7%	\$7,142	\$6,642	7.5%
1989	1994	\$181.7	\$178.9	1.6%	\$7,518	\$7,054	6.6%
1990	1995	\$181.1	\$188.8	-4.0%	\$7,553	\$7,401	2.1%
1991	1996	\$195.7	\$197.4	-0.9%	\$7,919	\$7,813	1.4%
1992	1997	\$211.4	\$210.7	0.4%	\$8,199	\$8,318	-1.4%
1993	1998	\$223.6	\$222.1	0.7%	\$8,566	\$8,782	-2.4%
1994	1999	\$238.2	\$233.0	2.2%	\$9,013	\$9,269	-2.8%
1995	2000	\$248.6	\$245.5	1.2%	\$9,347	\$9,873	-5.3%
Average Absolute Error (1998-2000):				1.4%	3.5%		
Average Absolute Error (1996-2000):				1.1%	2.7%		
Average Absolute Error (1985-2000):				5.2%	5.8%		

The regional economic forecast performance improvement can be attributed, in part, to the better performance of the national forecasts and to improvements in the TVA economic forecasting process, including validation procedures. TVA conducts reviews of forecasting performance (as per the example above) as well as annual reviews of new economic data. Economic "forecasts" over the historical period are conducted annually to test TVA's economic model performance versus actual data.

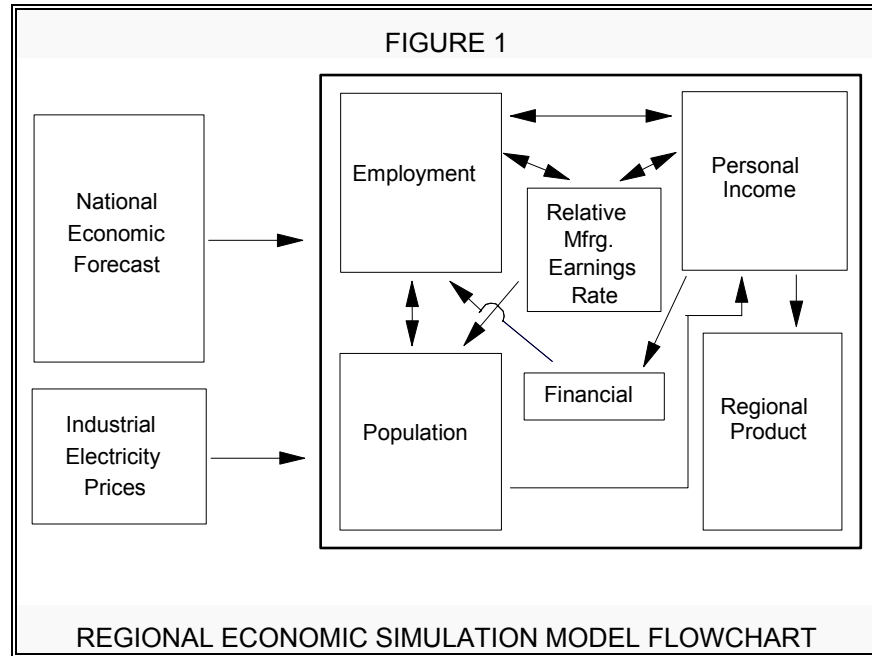
Use of Best Methods

TVA uses its regional economic simulation model (RESM) as its primary model to produce its base regional economic forecasts within an integrated system of models and analyses. The RESM model uses state-of-the-art statistical methods, comparable to those of the major

economic forecasters in the country. TVA has been a leader in the utility industry in the use of econometric forecasting models, which have now become the industry standard. Several professional papers have been presented on TVA's model and articles published on the subject and the resultant TVA forecast analyses; the analyses have been quoted in *The Wall Street Journal* and *USA Today* as well as the regional media.

As seen in Figure 1,

the two major inputs to RESM are *Global Insight* national economic forecasts and TVA industrial electricity prices. RESM does not just allocate national trends but captures the differences inherent in the regional economic



structure which affect regional performance. RESM is updated on an annual basis and has a high degree of industry detail. (For example, the model includes chemicals, apparel, etc., in manufacturing; food stores, health services, etc., in the commercial sector.) This allows for inter-industry linkages; for instance, wholesale trade is linked to retail trade. (See Gonzalez, Juan E., "The TVA Regional Economic Simulation Model," Proceedings: Eighth Electric Utility Forecasting Symposium, [EPRI TR-100396], Electric Power Research Institute, Palo Alto, California, April 1992, pp. 39-1 to 39-11, for a more detailed discussion of RESM.)

TVA uses other models in an integrated fashion with the RESM model to further enhance the accuracy and detail of its economic forecasts and analyses. TVA maintains a monthly econometric model that uses current United States Bureau of Labor Statistics monthly state employment data to allocate the annual TVA region economic forecast over the year. Even though this model lacks the detail of the annual model, it allows for continuous tracking and updating of the forecast on a monthly basis.

TVA has a multiarea economic simulation and forecasting model purchased from *Regional Economic Models, Inc.* (REMI). The REMI model is used along with the TVA econometric models to produce economic forecasts of TVA economic subregions and simulations of economic impacts for studies of economic development, transportation infrastructure, and electricity prices proposals. (See Appendix 2 for a detailed description of the REMI model.)

The REMI model provides a much more comprehensive set of economic relations than the more aggregate econometric models including detailed interindustry relationships within an input-output-type model and interlinkage of geographic subregions through simulation of interregional trade. While the econometric-based RESM has strong dynamic properties for producing accurate base trend economic forecasts, the REMI model enhances the forecast process through more extensive policy simulations of alternative scenarios and through allocation of TVA's regional economic forecasts to the economic subregions of the Valley.

As part of process improvement, TVA began a program with universities around the Valley to share economic information and review economic forecasts in 1985. Currently, there are 11 universities participating: The University of Alabama in Huntsville, Georgia State University, Eastern Kentucky University, Western Kentucky University, Mississippi State University, Austin Peay State University, East Tennessee State University, Middle Tennessee State University, The University of Memphis, The University of Tennessee at Knoxville, and The University of Tennessee at Martin. Besides providing current information on economic events in their specific subregions, the universities review both the regional economic forecast and the forecasts for the economic subregions of the Valley on an annual basis. Feedback is incorporated into the economic forecasting process and used to validate and revise the regional economic forecasts.

Besides regular review by these universities, TVA regional economic forecasts have been occasionally audited by other outside parties, including by the United States General Accounting Office as part of the Energy Vision 2020 study.

Use of Best Information

TVA strives to use the best information available for its economic forecasting. As mentioned, the national economic forecasts are purchased from *Global Insight*. *Global Insight* forecasts are well recognized and widely used. Among *Global Insight* clients are a great number of utilities, federal and state agencies, universities, and Fortune 500 companies. *Global Insight* forecasts are quoted by the *Wall Street Journal* and other major business publications and used in Congressional hearings and legal cases. In addition, TVA monitors national economic forecasts,

such as the survey done monthly by *Consensus Forecasts – USA*, as a “check” on the *Global Insight* national economic forecast.

The source historical economic data for the regional forecasts come from the federal government: the Bureau of Economic Analysis and the Bureau of the Census, United States Department of Commerce, and the Bureau of Labor Statistics, United States Department of Labor. The federal government has improved these data over the years. Further, TVA has improved its use of these data to get a better and more current picture of the regional economy. For example, by using the monthly state employment data from the Bureau of Labor Statistics, TVA can estimate regional employment in a more timely manner than by using estimates from other sources.

TVA has improved its information by supplementing the data discussed above with information from other sources including detailed employment and payroll data from state employment agencies, announcements of plant openings and closings, information on industry trends from trade journals and government reports, information from regional universities (discussed above), and the status of local industries from the TVA Customer Service and Economic Development staff. TVA also monitors Tennessee Valley state economic forecasts, such as the annual forecast article done by the Federal Reserve Bank of Atlanta, as a “check” on the TVA regional economic forecast.

Explicit Treatment of Uncertainty

Forecasting is inherently uncertain. First, uncertainty exists within the major inputs to the regional forecast. Many events, especially those that are not economic in nature such as the break up of the Soviet Union or the September 11, 2001, terrorist attack, may derail the national economy from its expected growth path. Likewise, TVA electricity price forecasts are uncertain. In addition, how the regional economic structure will change over time is uncertain.

To try to deal with uncertainty, TVA supplements its modeling with industry analyses and studies of specific major issues such as the effects of changes in the value of the dollar or interest rates on the Valley economy. This is an effort to continually improve TVA's understanding of the Valley economy and its ability to produce accurate economic forecasts.

Further, TVA deals with uncertainty by producing alternative regional economic forecasts such as the high and low forecasts that define a range of possible future economic outcomes with a 90 percent confidence that the true outcome will fall within this range. The high and low forecasts are derived by using *Global Insight* national high and low economic forecasts and TVA low and

high electricity price forecasts, respectively. Explicit assumptions are made as to possible events that are not considered most likely but are feasible developments from emerging historical events. Thus, for instance, in the current high economic forecast, the assumption is made that the region will develop a commercial sector that more closely matches that of the nation, including more “high-tech” business services. Likewise, in the low forecast, the assumption is made that several of the Valley's manufacturing industries, not just apparel, will experience large negative effects due to foreign competition.

Appendix 1

Average Absolute Percentage Error

Forecast versus Actual Values

		Last Five Target Years**				All Target Years**			
		One-Year Forecast	Two-Year Forecast	Five-Year Forecast	Ten-Year Forecast	One-Year Forecast	Two-Year Forecast	Five-Year Forecast	Ten-Year Forecast
Final Environmental Assessment	Gross Product*								
	Region	1.0%	1.3%	2.2%	9.6%	1.1%	2.3%	4.1%	17.2%
	US	1.0%	1.9%	1.3%	17.8%	1.0%	2.6%	6.1%	23.4%
	Manufacturing Product*								
	Region	2.6%	3.5%	8.3%	11.6%	2.0%	3.1%	7.2%	15.0%
	US	1.2%	2.3%	1.7%	15.9%	1.4%	3.2%	6.4%	21.3%
	Total Employment								
	Region	0.2%	0.6%	2.7%	6.4%	0.6%	1.4%	2.9%	5.7%
	US	0.6%	1.5%	1.2%	4.8%	0.5%	1.3%	1.6%	4.0%
	Manufacturing Employment								
	Region	1.3%	2.5%	6.2%	3.8%	1.4%	2.8%	3.5%	3.5%
	US	1.1%	2.9%	2.4%	3.4%	1.4%	3.4%	3.9%	6.5%
	Per Capita Income*								
	Region	0.4%	1.9%	2.8%	15.6%	1.1%	2.1%	3.5%	16.8%
	US	0.7%	2.0%	4.6%	18.9%	1.1%	2.1%	5.4%	20.9%

**“Last Five Target Years” represents the average absolute percentage error for forecasts of the years 1995-1999, the last five years for which actual data are available; “All Target Years” represents the average absolute percentage error for all years forecasted: one-year—1981-1999 target years, two-year—1982-1999, five-year—1985-1999, and ten-year—1990-1999.

APPENDIX 2

TVA'S REMI MODEL

In an effort to continue to improve its processes, TVA sought to purchase a model that would work in an integrated fashion with its econometric models to enhance TVA's economic forecasting and analysis capability in the area of economic interactions, impact analysis, and geographic detail. In 1997, TVA issued a request for proposals for a multiarea economic simulation and forecasting model. The model was to be used along with the existing TVA econometric models to produce economic forecasts of TVA economic subregions and simulations of economic impacts for studies of economic development, transportation infrastructure, and electricity prices proposals.

Necessary requirements for the economic model were as follows.

1. The model must be a multi-area model for the seven subregions, that is, the simulations and forecasts for any one subregion must be interlinked with and influence the results of the other subregions according to economic theory.
2. The model must have comprehensive economic sector detail. At a minimum, the model must be specified at the 2-digit standard industrial classification (SIC) level of sector detail in employment and income and product. The model must also provide information on major income aggregates, population, and labor force.
3. The model must provide this output over both short-term and long-term forecast horizons on a year-by-year basis.
4. The model must be sensitive to and capable of simulating the economic effects of changes in a variety of economic variables, specifically including labor costs and electricity prices.
5. The economic model must have a proven track record with publication of professional papers on the economic model and demonstrated use by other government agencies and electric utilities over several years.

The *Regional Economic Models, Inc.* (REMI), model met these requirements and was chosen. Since that time, TVA has used the REMI model as an integrated part of its economic forecasting and analysis process for its internal planning purposes and for a variety of projects as part of its mission as a regional development agency, including in collaborative studies with the United States Army Corps of Engineers.

The model is described in more detail below by REMI itself:

An Introduction to REMI and the REMI Policy Insight Model

Founded in 1980, *Regional Economic Models, Inc.* (REMI), constructs models that reveal the economic and demographic effects that policy initiatives or external events may cause on a local economy. REMI model users include national, regional, state, and city governments, as well as universities, nonprofit organizations, public utilities, and private consulting firms.

REMI Policy Insight, the newest version of REMI's software, combines years of economic experience with an easy-to-use software interface. A major feature of REMI is that it is a dynamic model which forecasts how changes in the economy and adjustments to those changes will occur on a year-by-year basis. The model is sensitive to a very wide range of policy and project alternatives and to interactions between the regional and national economies.

REMI Policy Insight includes a REMI model that has been built especially for the geographic areas in the users' customized version of the model. The model-building system uses hundreds of programs developed over the past two decades to build customized models for each area using data from the Bureau of Economic Analysis, the Bureau of Labor Statistics, the Department of Energy, the Census Bureau, and other public sources.

The REMI model is a structural model, meaning that it clearly includes cause-and-effect relationships. The model shares two key underlying assumptions with mainstream economic theory: households maximize utility, and producers maximize profits. These assumptions make sense to most people; thus, the model can be understood by interested lay people as well as trained economists.

In the model, businesses produce goods to sell to other firms, consumers, investors, governments, and purchasers outside the region. The output is produced using labor, capital, fuel, and intermediate inputs. The demand for labor, capital, and fuel per unit of output depends on their relative costs, since an increase in the price of any one of these inputs leads to substitution away from that input to other inputs. The supply of labor in the model depends on the number of people in the population and the proportion of those people who participate in the labor force. Economic migration affects the population size. More people will move into an area if the real after-tax wage rates or the likelihood of being employed increases in a region.

Supply and demand for labor in the model determine the wage rates. These wage rates, along with other prices and productivity, determine the cost of doing business for every industry in the model. An increase in the cost of doing business causes either an increase in price or a cut in profits, depending on the market for the product. In either case, an increase in cost would

decrease the share of the local and United States market supplied by local firms. This market share combined with the demand described above determines the amount of local output. Of course, the model has many other feedbacks. For example, changes in wages and employment affect income and consumption, while economic expansion changes investment, and population growth impacts government spending.

Model Evaluation

REMI's continuous research effort to refine, expand, and improve the model has been underway since 1980. The model and supporting research is documented in professional journals, including *The American Economic Review*, *The Review of Economics and Statistics*, *Growth and Change*, *The Journal of Regional Science*, and *The International Regional Science Review*.

The widespread use of the REMI methodology throughout the United States has led to extensive documentation of the value of using the REMI model in socioeconomic analysis. For example, the South Coast Air Quality Management District (SCAQMD) commissioned a \$200,000 study for the Massachusetts Institute of Technology (MIT). The study (hereafter referred to as "the MIT study") evaluated the REMI methodology and the entire socioeconomic analysis system that SCAQMD uses to obtain the impacts of implementing air pollution controls on the Los Angeles Basin. The MIT study evaluated REMI and other socioeconomic analysis models for SCAQMD, and came to the following conclusions:

"REMI has the following seven features often unavailable in many other microcomputer-based regional forecasting models:

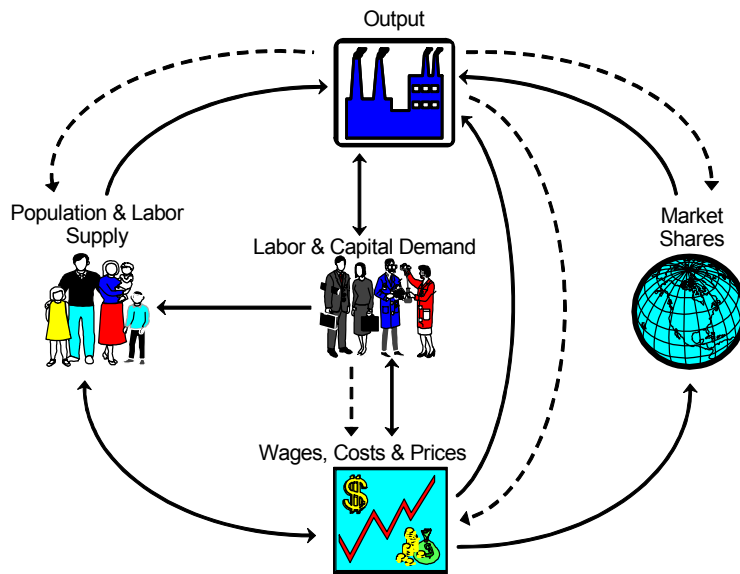
1. It is calibrated to local conditions using a relatively large amount of local data, which is likely to improve its performance, especially under conditions of structural economic change.
2. It has an exceptionally strong theoretical foundation.
3. It actually combines several different kinds of analytical tools (including economic-base, input-output, and econometric models), allowing it to take advantage of each specific method's strengths and compensate for its weaknesses.
4. It allows users to manipulate an unusually large number of input variables and gives forecasts for an unusually large number of output variables.
5. It allows the user to generate forecasts for any combination of future years, allowing the user special flexibility in analyzing the timing of economic impacts.
6. It accounts for business cycles.
7. It has been used by a large number of users under diverse conditions and has proven to perform acceptably."

Model Overview

The figure below is a pictorial representation of the model. Output (block 1) shows a factory that sells to all the sectors of final demand as well as to other industries. Labor and Capital Demand (block 2) shows how labor and capital requirements depend both on output and their relative costs. Population and Labor Supply (block 3) are shown as contributing to demand and to wage determination in the product and labor market. The feedback from this market shows that economic migrants respond to labor market conditions. Demand and supply interact in Wage, Price, and Profit (block 4). Once prices and profits are established, they determine Market Shares (block 5), which along with components of demand, determine output.

The REMI model brings together all of the above elements to determine the value of each of the variables in the model for each year in the baseline forecasts. The model includes all the interindustry relationships that are in an input-output model in the Output block, but goes well beyond the input-output model by including the relationships in all of the other blocks shown in the figure.

REMI (2002) Model Structure



Economic Geography Linkages (dashed lines)

In order to broaden the model in this way, it was necessary to estimate key relationships. This was accomplished by using extensive data sets covering all areas in the country. These large data sets and two decades of research effort have enabled REMI to simultaneously maintain a theoretically sound model structure and build a model based on all the relevant data available.

The model not only simulates what will happen but, through its dynamic properties, simulates when it will happen. This results in long-term predictions that have general equilibrium properties. This means that the long-term properties of general equilibrium models are preserved without sacrificing the accuracy of event timing predictions and without simply taking elasticity estimates from secondary sources.

These properties are fully used in the policy simulation process for a scenario. The effects of a scenario are determined by comparing the baseline REMI forecast with an alternative forecast that incorporates the assumptions for the scenario.

Model Structure

The structure of the model incorporates interindustry transactions and endogenous final demand feedbacks. In addition, the model includes: substitution among factors of production in response to changes in relative factor costs, migration in response to changes in expected income, wage responses to changes in labor market conditions, and changes in the share of local and export markets in response to changes in regional profitability and production costs.

The power of the REMI model lies in its use of theoretical structural restrictions instead of individual econometric estimates based on single time-series observations for each region. The explicit structure of the model facilitates the use of policy variables that represent a wide range of policy options and the tracking of the policy effects on all the variables in the model.

The inclusion of price responsive product and factor demands and supplies give the REMI model much in common with Computable General Equilibrium (CGE) models. CGE models have been widely used in economic development, public finance, and international trade, and have been more recently applied in regional settings. Static CGE models usually invoke market clearing in all product and factor markets. Dynamic CGE models typically assume perfect foresight, intertemporal clearing of markets, or temporary market clearing if expectations are imperfect. The REMI model differs, however, because product and factor markets do not clear continuously. The time paths of responses between variables are determined by combining a priori model structure with econometrically estimated parameters.

Although the model contains a large number of equations, five blocks describe the underlying structure of the REMI model. Most interactions flow both ways indicating a highly simultaneous structure. Block 1, output linkages, forms the core of the model. An input-output structure

represents the interindustry and final demand linkages by industry. The interaction between block 1 and the rest of the model is extensive. Predicted outputs from block 1 drive labor demand in block 2. Labor demand interacts with labor supply from block 3 to determine wages. Combined with other factor costs, wages determine relative production costs and relative profitability in block 4 affecting the market shares in block 5. The market shares are the proportions of local demand in the region in block 1 and exogenous export demand that local production fulfills.

The endogenous final demands include consumption, investment, and state and local government demand. Real disposable income drives consumption demands. An accounting identity defines nominal disposable income as wage income from blocks 2 and 4, plus property income related to population and the cohort distribution of population calculated in block 3, plus transfer income related to population less employment and retirement population, minus taxes. Nominal disposable income deflated by the regional consumer price deflator from block 4 gives real disposable income. Optimal capital stock calculated in block 2 drives stock adjustment investment equations. Population in block 3 drives state and local government final demand. The endogenous final demands combined with exports drive the output block.

The use of the REMI model for analysis of policy effects is a two-step process. First, a baseline forecast that uses a national forecast as one of the inputs is generated by the model. The baseline REMI forecast uses recent data and thousands of equations to generate projected economic activity for a particular region. The policy variables in the model are set equal to their baseline value when solving for the baseline forecast. To show the effects of a given scenario, these policy variables are given values that represent the direct effects of the scenario. Second, the direct effects of a policy change are input into the REMI model to generate a forecast for the local economy with the policy change (alternative forecast). The alternative forecast is generated using these policy variable inputs. The difference between the baseline and alternative forecasts thus gives the total effects of a policy change.

Direct effects of a policy change are input to the REMI model through a large set of policy variables. They include industry-specific variables, cohort-specific variables for 808 age-gender-race cohorts, and final demand-specific variables for 25 final demand sectors. The policy variables cover a wide range of possible types of inputs that make it possible to analyze any policy that may affect a subnational area.

Economic geography linkages (indicated by the dashed arrows in the figure) account for the effects of agglomeration in both the labor and product markets. These effects are crucial to

accurately capture the key to why certain areas that have a concentration of similar businesses can prosper despite high wages and real estate costs. The reason is that by having a choice of suppliers and workers, each firm can obtain specialized labor and inputs that best fulfill their needs. This increases productivity and efficiency. Nashville's agglomeration of musical artists, producers, recording studios, show case venues, songwriters, agents, entertainment lawyers, etc., is the perfect example of an agglomeration economy.

The dashed arrow from the output block to the cost block shows that more suppliers will increase the efficiency of inputs, which will then reduce production costs and competitiveness. The dashed arrow from the labor block shows that more labor will increase the productivity of labor, thus reducing labor costs and thereby making the area more competitive, i.e., more songwriters migrating to Nashville bring in better ideas. The arrow from output to the population block shows that the greater output provides more variety of choices and enhances consumer satisfaction, and thus inward migration. The arrow from the output to the shares block shows that the areas with concentration can offer more to purchasers, thus having an effect on market share in addition to the price advantages through the cost and price block.